Advanced Programming

Interfaces

What is an interface?

Webster: “a place at which *independent and often unrelated systems* meet and communicate with each other“, respecting a set rules .

Contract, Protocol

- An interface describes a model, a contract.
- A class may implement that model, adhering to the contract and strictly respecting its specifications.

Defining an Interface

```
[public] interface InterfaceName
  [extends SuperInterface1, SuperInterface2...] {
    /* Constant declarations
       Abstract methods
       Default methods
       Static methods */
}
```

Examples:

```
public interface Student {
    int MAX_GRADE = 5;          //public static final int ...
    int getExamGrade();         //public abstract int ...
}
public interface AutoCloseable {
    void close();
}
public interface Observer {
    update(Observable o, Object arg);
}
```

Implementing an Interface

```
class ClassName implements Interface1, Interface2, … {
    /* A concrete class that implements an interface
     must specify code for all abstract methods
     declared by the interface */
}
```

Examples:

```
public class InfoStudent implements Student {

   public int getExamGrade {

     return MAX_GRADE;

   }

}

public class EagleEye implements Observer { … }

public class FileReader implements AutoCloseable { … }

public class Connection implements AutoCloseable { … }
```

Interface – Reference Type

We may say that an object is of type X, where X is an interface, if that object is an instance of a class implementing the interface X.

```
Student student = new InfoStudent();
```

~~`Student student = new Student();`~~

```
Observer observer = new EagleEye();
```

~~`Observer = new Observer();`~~

```
AutoCloseable reader = new FileReader("fis.txt");
```

~~`AutoCloseable reader = new AutoCloaseable();`~~

Multiple Implementations

```
public interface Matrix {
  void set(int row, int col, double value);
  double get(int row, int col);
  Matrix add(Matrix m);
  Matrix mul(Matrix m);
  …
}
public class DefaultMatrixImpl implements Matrix {
  private double[][] data;
  public DefaultMatrixImpl(int rows, int cols) { … }
  …
}
public class SparseMatrixImpl implements Matrix {
  private int[] row;
  private int[] col;
  private double[] data;
  public SparseMatrixImpl(int rows, int cols) { … }
  …
}
public static void main ( String args []){
  Matrix a = new DefaultMatrixImpl(10, 10); a.set(0,0, 123); …
  Matrix b = new SparseMatrixImpl (10, 10); b.set(9,9, 456); …
  Matrix c = a.add(b);
}
```

Interfaces and Abstract Classes

- Extending an abstract class imposes a strong relationship among two classes.
- Implementing an interface is much lighter: it only specifies that a class is respecting a certain contract, making sure it conforms to some specifications.
- Interfaces and abstract classes do not exclude each other, they are used together in many situations:
  - `List` → the contract
  - `AbstractList` → the common behaviour
  - `LinkedList`, `ArrayList` → specific behaviour

Evolving Interfaces

- Add another abstract method to an interface → all classes that implement it will break.

```
public interface Matrix {
    …
    void reset(); //we add a new abstract method to the interface
}
```

- Anticipate all uses for your interface and specify it completely from the beginning!
- Create a new interface, extending the old one
  - Old classes will use the old interface or upgrade to the new interface.
- Use default methods.

Default and Static Methods

- Default methods allow extending interfaces without having breaking implementations.

```
public interface Matrix {
    …
    default void reset() {
      for (int i = 0; i < rowCount(); i++) {
         for (int j = 0; j < columnCount(); j++) {
             set(i, j, 0);
         }
      }
    }
```

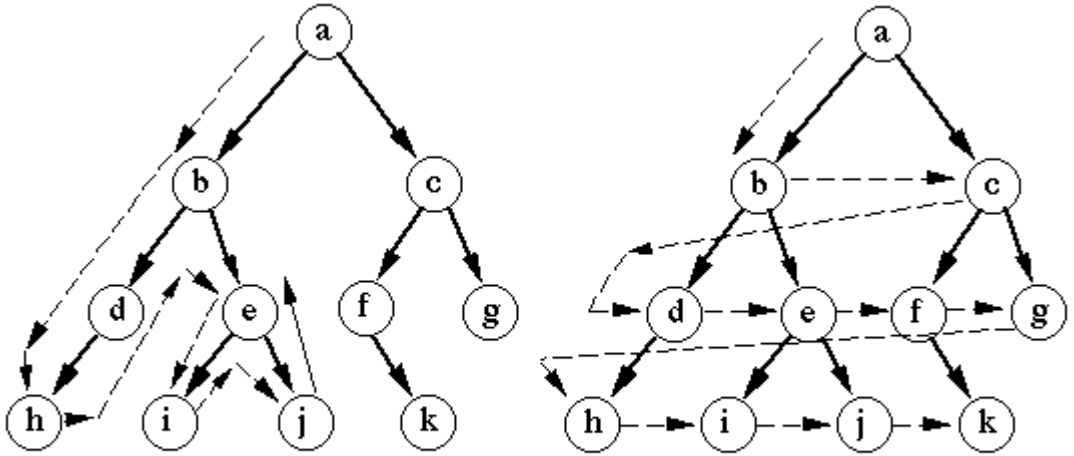
- Classes may override default methods.
- Static methods are similar to default methods except that we can't override them.

```
    static void log(String str) {
        System.out.println("Logging: " + str);
    }
```

Callback Methods

A callback is something that you pass to a method as an argument (some piece of code).

Example: *When a graph exploration algorithm reaches a node, we want to execute some kind of processing for that specific node.*



Implementing *Callback* Methods

```
public interface NodeProcessing {
  public void execute(Node u);
}

public class Graph {
  …
  public void explore(NodeProcessing f) {
    …
    if (exploration reached the node v) {
      f.execute(v);
    }
    …
  }
}
//Implement various processing types
class PrintRo implements NodeProcessing {
  public void execute(Node v) {
    System.out.println("Nodul curent este: " + v);
  }
}
class PrintEn implements NodeProcessing {
  public void execute(Node v) {
    System.out.println("The current node is: " + v);
  }
}
```

```
Graph g = new Graph();
…

g.explore(new PrintRo());

g.explore(new PrintEn());
```

FilenameFilter Interface

```
//Listing the files from a folder
import java.io.*;

public class ListFiles {

  public static void main ( String [] args ) {
      File folder = new File(".");
      String[] list = folder.list(new MyFilter("mp3"));
      for (int i = 0; i < list.length ; i ++) {
        System.out.println(list[i]);
      }
  }
}

class MyFilter implements FilenameFilter {
  String extension;

  public MyFilter (String extension) {
    this.extension = extension;
  }
  public boolean accept(File dir, String name) {
    return name.endsWith("." + extension);
  }
}
```

Anonymous Classes

Anonymous Class = Inner class used to create an object of a specific type.

```
method(new SomeInterface() {
  // Implement interface methods
});
```

Example:

```
folder.list(new FilenameFilter() {
  // Anonymous class
  public boolean accept (File dir, String name) {
    return ( name.endsWith(".txt") );
  }
});
```

Compile: `OuterClass$1.class, OuterClass$2.class, ...`

Comparing Objects

```
class Person {
  private int code;
  private String name;
  public Person (int code, String name ) {
    this.code = code;
    this.name = name ;
  }
  ...
  public String toString () {
    return code + " \t " + name;
  }
}

class Sorting {
  public static void main ( String args []) {
    Person persons[] = new Person[4];
    persons[0] = new Person (3, " Ionescu ");
    persons[1] = new Person (1, " Vasilescu ");
    persons[2] = new Person (2, " Georgescu ");
    persons[3] = new Person (4, " Popescu ");
    java.util.Arrays.sort(persons);
    System.out.println ("The persons were sorted...");
    for (int i = 0; i < persons. length ; i++)
      System.out.println (persons[i]);
    }
}
```

The *Comparable* Interface

Imposes a total ordering on the objects of a class (*natural*)

```
public interface Comparable {
  int compareTo(Object o);
}
```

```
class Person implements Comparable {
  …

  public int compareTo (Object other) {
  //returns: 0 if this==other, <0 if this<other, >0 if this>other

    if (other == null )
      throw new NullPointerException();
    if (!( other instanceof Persoana ))
      throw new ClassCastException ("Uncomparable objects!");

    Person pers = (Person) other;
    return (this.code - pers.code);
  }

}
```

The *Comparator* Interface

A comparison function, which imposes a total ordering on some collection of objects

```
import java.util.*;
class Sorting {
  public static void main ( String args []) {
    Person persons[] = new Person [4];
    persons[0] = new Person (3, " Ionescu ");
    persons[1] = new Person (1, " Vasilescu ");
    persons[2] = new Person (2, " Georgescu ");
    persons[3] = new Person (4, " Popescu ");
    Arrays.sort (persons, new Comparator () {
      public int compare ( Object o1 , Object o2) {
        Person p1 = (Person)o1;
        Person p2 = (Person)o2;
        return p1.getName().compareTo(p2.getName());
      }
    });
    System.out.println("The persons are orderd by name:");
    for (int i = 0; i < persns.length; i++)
      System.out.println (persons[i]);
    }
  }
}
```

Functional Interfaces

- A functional interface is any interface that contains only one abstract method.
- Instead of using an anonymous class, you use a *lambda expression*, omitting the name of the interface and the name of the method.

```
Arrays.sort(p, (Object o1, Object o2) -> {
    Person p1 = (Person) o1;
    Person p2 = (Person) o2;
    return p1.getName().compareTo(p2.getName());
});
```

```
@FunctionalInterface
public interface Comparator { ...}
```

Method References

- Sometimes a lambda expression does nothing but call an existing method.

```
class Person {
    ...
    public static int compareByAge(Person a, Person b) {
      return a.birthday.compareTo(b.birthday);
    }
}
```

```
Arrays.sort(persons,(a, b) -> Person.compareByAge(a,b));
```

- In those cases, it's often clearer to refer to the existing method by name:

```
Arrays.sort(persons, Person::compareByAge);
```

Marker Interfaces

- Interfaces that do not define any method.

```
interface Serializable {}

interface Cloneable {}
```

- Their role is to associate some *metadata* to a class, that will be useful at runtime.

```
class Person
    implements Serializable, Cloneable { … }
```

- A modern alternative: *annotations*

```
@Entity(table="persons")
class Person { … }
```

Conclusions

- An interface defines a set of specifications
- They are essential in separating the model from the implementation.
- An interface is a common denominator between unrelated classes.
- Can be used as Reference Data Types
- Can be used to implement *Callbacks*